Overview of the VPIphotonics Simulation Demos

For use with *Optical Communications Essentials*
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General Notes

Note 1: The simulation demos listed below can be run with the simulation tool "VPIplayer" from VPIphotonics. This tool can be downloaded from the Web at www.VPIphotonics.com. Currently the demos are available at www.mhhe.com/keiser and are located under the button entitled "VPIplayer Demo Set 1." Please download the demo files to your computer before trying to use them with the VPIplayer.

Note 2: After downloading VPIplayer, click on the "?" button on the top right of the VPIplayer screen to open the Help manual. It is recommended that users read through this before starting to use VPIplayer.

Once the demo files are downloaded, open the VPIplayer program and use the bottom leftmost button on the VPIplayer screen to select which simulation demo to run.

Note 3: To view a certain area of the VPIplayer layout window in greater detail, place the cursor over the area of interest and right-click on the mouse. Left-click on "Zoom in" to enlarge the selected area. Right-clicking anywhere on the enlarged area and selecting "original View" returns the screen back to the original state. See the Help menu for more details.

Note 4: In several demos the user can change the value of dispersion in the Global Parameters table of the Channel Analyzer display after the simulation has been run. To have the program accept the new value before rerunning the simulation, the user first must click either in another box or click "Enter" on the keyboard.

Note 5: In the Channel Analyzer display, clicking on the right-most icon on the top of the display will give a bit error rate (BER) curve. First click this icon and then click on Plot in the window that opens.

Note 6: The demos listed below have varying levels of complexity. (a) For simple demonstrations of various concepts, try following modules: 1, 2, 3, 5, 6, 11, and 14. (b) The following modules give displays showing basic concepts, but their parameters can be varied for more extensive comparisons: 10, 12, 15, 16, and 17. (c) The use and interpretation of the other modules are a little more complex: 4, 7, 8, 9, 13, and 18.

Notes on the Specific VPIplayer Demos

1. **BER vs Dispersion**: (Chap 4 and 14) This demo shows the effects of chromatic dispersion on signal quality. This is exhibited in terms of an eye diagram. As described in Chapter 7, the opening in an eye pattern is related to the ability to

interpret a digital signal accurately and gives an estimate of the BER. After the simulation has run, the display labeled "EYE" shows the signal quality after 10 units of 200 ps/nm of dispersion. To see the progressive signal-degrading effects of dispersion over increasingly longer transmission distances, uncheck the "Continuous" box under TRACE and scroll back to 1/10 using the "<<" button.

2. **BER vs Extinction Ratio**: (Chap 15 and 16) This demo illustrates the BER as a function of the extinction ratio (ER) for a system without optical amplifiers. Recall that the ER is the ratio of the mean power in a 1 pulse to the mean power in a 0 pulse. Note in the simulation display that as the ER decreases from 13 dB to 4 dB (that is, as the ratio of mean power in a 1 pulse to the mean power in a 0 pulse decreases), the BER curve moves up. This causes a power penalty of approximately 3.4 dB at any specific BER for a non-amplified system when the ER changes from 13 to 4 dB. Compare the results with those of the amplified system described in Demo #3.

3. **BER vs Extinction Ratio (Amplified System)**: (Chap 15 and 16) This extension of Demo #2 includes the effects on ER when an optical amplifier is included in the system.

4. **BER vs ROP with Channel Analyzer**: (Chap 16) This setup provides an efficient method of calculating and plotting BER versus Received Optical Power. See Note 3 above on obtaining a plot of BER versus Received Power and on changing the value of the optical fiber dispersion.

5. **Black Box versus Full EDFA model (980nm Pump)**: (Chap 11, 12, 13, and 16) This demo compares three different simulation models. Some suggestions for this demo: Compare the noise figure (NF) and gain for different pump powers. See also Demos 10, 11, and 12 for further detailed simulations.

6. **Black Box versus Full EDFA model (1480nm Pump)**: (Chap 11, 12, 13, and 16) Same comment as for Demo #5.

7. **CNR, CSO, CTB, IMD CATV Measurements**: (Chap 14) This demo illustrates various performance parameters of a 20-channel NTSC analog system. See the VPIplayer notes for use of this demo and the accompanying Readme.PDF file for interpretation of the simulation displays.

8. **Directly Modulated Laser System**: (Chap 4, 6, 15, and 16) This setup shows how the chirped output waveform from a directly modulated laser interacts with fiber dispersion to cause pulse spreading. (a) In the display window called "SCOPE: Power & Frequency Waveforms" the user can either zoom in to see the details or use the mouse to select an area of interest. (b) Clicking on either the LPF (low pass filter) or the ITU button under the "Bandwidth" box reduces the noise and allows a better view of the transient chirp. (c) Note that when using the OC-192 rate, the BER scale does not show up if there is less than one order of magnitude difference. (d) Note that six

parameters can be changed; use the bottom arrows in the slider window to view all six parameters.

9. **Dispersion Managed Sections**: (Chap 15 and 16) This setup demonstrates the use of dispersion compensating fiber (DCF) to mitigate the effects of chromatic dispersion in a link. Different fiber span lengths and attenuation values can be selected. (a) After running the simulation, uncheck the "Continuous" box and click on the "Eye" icon (third icon from the right at the top of the Channel Analyzer display). Scroll back to 1/5 using the "<<" button to see the change in the eye diagram with successive spans of fiber. (b) Check the BER when the eye opening is reasonably apparent. Note the effect of dispersion on the BER at different wavelengths.

10. **EDFA Gain and Noise Figure Characterization**: (Chap 10, 11, 13, 14, and 16) This demo characterizes the gain and noise figure of an EDFA. Note the gain tilt across the various WDM channels. See the VPIplayer notes for use of this demo and the accompanying Readme.PDF file for interpretation of the simulation displays.

11. **EDFA Gain versus Input Power**: (Chap 10, 11, 13, 14, and 16; e.g., see Fig. 11.4 in Chap. 11) This illustrates the gain versus optical input power characteristics of an EDFA. See the accompanying Readme.PDF file for interpretation of the simulation displays.

12. **EDFA Preamplifier Design**: (Chap 11) This demo allows many variations on EDFA design configurations, such as 980 or 1480 nm pump wavelengths, forward or backward pumping, and different EDF lengths. See the VPIplayer notes for use of this demo and the accompanying Readme.PDF file for interpretation of the simulation displays.

13. **Four Wave Mixing**: (Chap 15) This demo illustrates the growth of four-wave mixing effects. The simulation takes some time to run, since it goes through 50 loop cycles. (a) During the simulation the user can see the changes in the eye diagrams with each successive simulation loop. After running the simulation, uncheck the "Continuous" box in the EYE display. Scroll back to 1/50 using the "<<" button to see the change in the eye diagram with successive simulation loops of fiber. (b) Clicking on either the LPF (low pass filter) or the ITU button under the "Bandwidth" box in the EYE display reduces the out-of-band crosstalk and allows a better view of the eye. (c) See the VPIplayer notes for some suggested use of this demo and the accompanying Readme.PDF file for discussion of the theory and interpretation of the simulation displays.

14. **NRZ Pre/Post Compensation**: (Chap 15 and 16) This module compares the effectiveness of three different dispersion compensation methods for NRZ formatted signals. See the VPIplayer notes for use of this demo and the accompanying Readme.PDF tutorial file for interpretation of the simulation displays.

15. **OSNR vs Transmission Distance**: (Chap 11, 14, 15, and 16) This demo shows the build-up of ASE noise along an amplified link. In the "XY: Power, Noise, and OSNR vs. Distance" display, the top trace gives the OSNR. This appears almost as a solid line on a small scale. Enlarge the display and then zoom in to see the degradation in OSNR at each amplifier because of ASE noise. The center curves give the optical power levels in the link as a function of distance and the bottom traces show the noise powers. Notice the gain tilt between the different WDM channels in the OSA display (zoom in to see details).

16. **Raman Gain Characterization**: (Chap 11 and 13) This setup demonstrates how to measure the gain of a distributed Raman amplifier. In the "XY: Power Distribution" display, the top curve is the optical power level in the fiber from the Raman pump laser (using backward pumping). The bottom set of curves are the signal power levels for the different WDM channels. Note the amplification effect on different wavelengths, which ranges from zero to about 12 dB. Use the mouse to zoom in on specific areas of interest. In the OSA display, the top curve gives the signal spectra and the bottom curve represents the noise spectra.

17. **Relative Intensity Noise**: (Chap 14) This setup shows how the relative intensity noise (RIN) can be determined as a function of the frequency. On the RF spectrum analyzer display (RFSA: Relative Intensity Noise) follow the directions in green on the VPIplayer setup diagram (or the ones in the "Relative Intensity Noise.PDF" tutorial) to see a smoother average value of the RIN versus frequency curve. Check the effect on the peak RIN value when the laser bias current changes. See the VPIplayer notes for use of this demo and the accompanying tutorial for interpretation of the simulation displays.

18. **Time-Resolved Frequency Chirp**: (Chap 6, 15, and 16) This module shows how to characterize the dynamic chirp of a laser. (a) In the display window called "SCOPE: Power & Frequency Waveforms" the user can either zoom in to see the details or use the mouse to select an area of interest. (b) Clicking on either the LPF (low pass filter) or the ITU button under the "Bandwidth" box reduces the noise and allows a better view of the transient chirp.